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MEMORANDUM FOR THE RECORD

Declass Review by NGA.

SUBJECT: Laser Hazards and Safety

The term "laser" is the acronym for light amplification by stimulated emission of radiation. The development of lasers during the past few years has proceeded with great speed. In fields ranging from communications to neurosurgery, lasers promise to provide invaluable assistance to the working scientist. As with most boons to civilization, however, several drawbacks are inherent in these revolutionary devices. Most severe of these drawbacks, and of most potential concern to this Staff, is the laser's proven role as a unique health hazard. Our use of experimental lasers in the Exploratory Development Laboratory should be brought to the attention of all Staff personnel, and proper precautions against possible injury should be well known by persons with only occasional exposure to the laser laboratory as well as by those experiencing frequent contact.

Laser-induced trauma has been the recent concern of such Government organizations as the Army's Office of the Surgeon General, the Atomic Energy Commission's Lawrence Radiation Laboratory at the University of California, the Armed Forces Institute of Pathology, and the Harry Diamond Laboratories of the Army Materiel Command. Eye damage has been shown to be of greatest incidence, especially with relatively low-powered, laboratory lasers, but cranial and dermatological effects have also been conclusively substantiated. Our chief interest here is with ocular injury.

At present, all experimental results available on retinal damage stem from studies conducted with rabbits. It must be emphasized that direct correlation between these results and effects upon the human retina are only assumed, not proven. In any case, these investigations have established thresholds for irreversible retinal lesions, which are regarded with large margins of safety for human considerations. Order of magnitude calculations based upon equal retinal sensitivities of rabbit and man indicate that direct viewing of even a one milliwatt gas laser at a wave-length of 6328 Angstroms is extremely hazardous. (Our presently employed laser is the
X1 [redacted] Model "5200" with a power of $\frac{1}{2}$ milliwatt at 6328A. The EDLB is contemplating the purchase of an additional device operating at $1\frac{1}{2}$ milliwatts). Even incoherent radiation from photographic arc

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lamps and solar eclipses has been known to induce tissue damage. (The laser, by definition is coherent, but it can be operated in a multiple mode whose radiation is incoherent and often highly dangerous.) Partial or total blindness is the outcome of a retinal burn, and no rehabilatory treatment is possible. In addition to this more common type of eye injury, one case-history has been reported where a detached retina and total blindness in one eye resulted from rubbing the eye after an accidental laser impact caused partial liquefaction of the ordinarily jelly-like vitreous humor. Numerous legal actions have been taken against the Government recently by laboratory workers incurring eye damage from laser exposure.

Two primary methods of protecting the eyes from the extremely high energy of lasers have been proposed. One, that of using either an interference or absorption filter in protective goggles, is now common practice. American Optical, Bausch & Lomb, TRG-Control Data, and Fish-Schurman are the leading manufacturers of these goggles, but no firm guarantees are made as to absolute thresholds of safety. The other method is that of using a phototropic material in the goggles which would blacken instantaneously at the rise of the arriving light pulse and clear upon its decay. This potential method is relatively unexplored, but it is very doubtful that sufficient opacity could be achieved in the required response time, on the order of 1/100 micro-second.

Our laboratory's use of lasers is confined to the continuous wave type, rather than the more powerful and much more dangerous pulsed variety. Nevertheless, our concern for personnel safety should not be minimized. Accordingly, the following tentative, but basic guidelines, derived from the First Annual Conference on Biologic Effects of Laser Radiation of the Federation of American Societies for Experimental Biology, and from the Second Conference on Laser Technology held at the Illinois Institute of Technology and sponsored by ARPA and the Tri-Services, are set forward:

"1) The laser beam should be discharged into a background that is non-reflective and fire resistant.

2) An area should be cleared of personnel for a reasonable distance on all sides of the anticipated path of the laser beam.

3) Looking into the primary beam must be avoided at all times, and equal care should be exerted to avoid looking at specular reflections of the beam, including those from lens surfaces.

4) Avoid aiming the laser with the eye, to prevent looking along the axis of the beam, which increases the hazard from reflections.

5) Work with lasers should be done in areas of high general illumination to keep pupils constricted and thus limit the energy which might inadvertently enter the eyes.

6) Some laser electronic-firing systems may store a charge, and caution must be exercised to avoid accidental pulsing of the laser and to avoid electric shock. Systems should be designed to prevent this hazard and to establish a 'fail-safe' condition. /Precaution against an exploding gas tube should also be exercised./

7) Individuals working in laser test procedures, and others frequently exposed to laser discharges, should be included in an occupational vision program which encompasses thorough, general ophthalmologic examinations at regular intervals. Such examinations will not neglect slit-lamp and funduscopic studies and mapping of the visual fields.

8) Safety eyewear designed to filter out the specific frequencies characteristic of the system affords protection, but it may be only partial.

In applying these guides the following facts should be kept in mind:

1) An acceptable threshold limit for exposure has not been established. Possibly a series of levels for different types of exposures - nanosecond pulses, millisecond pulses, continuous wave - may be indicated. Only time will resolve this question. In the meantime, it is suggested that the conservative approach delineated above be used.

2) The effects of atmospheric refraction upon the beam still remain to be measured.

3) Atmospheric attenuation needs to be measured.

4) Mirror reflections may cause as much biologic damage as the original beam. Glass surfaces may reflect 4% of the beam energy, which itself may be sufficient to cause retinal damage. /A recent, rather disconcerting instance has been documented in which an experimenter actually incurred permanent damage from a reflection off a piece of chalk!/ The fact that the beam may be invisible from certain sources (such as the neodymium solid-state laser) makes recognition of reflections even more difficult."

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Development Branch, P&DS